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APPLICATION FOR UNITED STATES LETTERS PATENT**

Method and Device for Cleaning Optical Connectors

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TITLE

Method and Device for Cleaning Optical Connectors

CROSS-REFERENCE TO RELATED APPLICATIONS

None.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable.

REFERENCE TO A MICROFICHE APPENDIX

Not applicable.

FIELD OF THE INVENTION

[0001] This invention generally relates to the art of fiber optic connectors and, particularly, to an optical connector cleaning device and a method for using such a cleaning device to clean optical connectors at optical connector junction job sites or in the manufacturing process thereof.

BACKGROUND OF THE INVENTION

[0002] Fiber optic connectors of a wide variety of designs have been employed to terminate optical fiber cables and to facilitate connection of the cables to other cables or other optical fiber transmission devices. In general, typical fiber-optic connectors include a ferrule which mounts and positions an optical fiber or fibers within the connector. The ferrule may be fabricated of such material as ceramic or glass filled resin. A ferrule holder or other housing component of the connector embraces the ferrule and may be fabricated of such material as molded plastic. A spring may be disposed within the housing or ferrule holder such that the ferrule is yieldably biased forwardly for engaging another fiber-mounting ferrule of a mating connecting device.

[0003] For instance, in the case of a single fiber connector, an optical fiber may be bonded at the center of a cylindrical rod called a cylindrical ferrule; the cylindrical ferrule is inserted into a precisely-formed cylindrical hollow portion of an alignment sleeve of the connector, so that two opposing ferrule end surfaces can be butted and connected to each other for the alignment of two opposite fibers. Further, in the case of a multi-fiber connector, a plurality of fibers may be arranged in predetermined positions and bonded to a resin cubic body called as a cubic ferrule; and then two cubic ferrules may be engaged with each other via two guide pins and two small-diameter guide holes so that two opposing ferrule end surfaces of a plurality of arranged fibers are butted and connected to each other for the alignment of two opposite fibers, respectively.

[0004] Such fiber-optic connectors typically are connected end-to-end. In other words, two opposite end surfaces of opposing ferrules are mated to directly connect opposing end surfaces of the optical fibers to each other. The connectors should provide excellent connection characteristics. However, major problems are encountered if the ferrule end surfaces become contaminated by dust, oil or other contaminants which will cause the connection characteristics to become markedly deteriorated.

[0005] In order to solve the contamination problems, cleaners have been provided to clean the ferrule end surfaces of fiber-optic connectors. The cleaners typically include some form of soft cloth or paper which is moved over the ferrule end surfaces. The cloth or paper may be dampened with a cleaning solution such as ethanol. Fluorocarbon gas may also be used to remove excessive ethanol and any cloth or paper dust.

[0006] While cleaners of the character described above have proven effective for their intended purposes, they have limitations in that the fiber-optic connectors typically are "brought to" the cleaner or there is easy access of the cleaner to the connectors. In other words, the

connectors are easily moved to positions in engagement with the cleaner. Such cleaners are extremely difficult to use and, often, are not effective where there is limited access to the connectors, such as where the connectors are located in a remote or confined area. Still further, it is difficult, if not impossible, to use most existing cleaners on the ferrule end surfaces of connectors which are mounted in adapter assemblies. The connectors must be removed from the adapters in order to be cleaned. This problem equally exists when a ferrule end surface is located inwardly or recessed within a mating end face of a connector.

[0007] Other methods of cleaning ferrule end surfaces have included the use of adhesive heads in an attempt to get contaminants to stick to the heads without leaving adhesive behind as an additional contaminant and the use of various cassettes with advancing mechanisms. In such cassettes, the ferrule end is typically cleaned by contact with a thin strip of fibrous non-adhesive tape or fabric which is exposed from the cassette. The cleaning contact is initiated either by moving the ferrule end across the strip or advancing the strip past the ferrule end. An example of the latter may be seen in U.S. Patent 6,209,162. These use a mechanism similar to those used for cleaning the magnetic heads in audio cassettes and VCR's, which typically incorporate the use a tape made of fibrous material to abrade the surface to be cleaned.

SUMMARY OF THE INVENTION

[0008] One embodiment of the present invention addresses an optical connector cleaning device for cleaning a ferrule end surface of an optical connector. The device includes a cleaning rod and a drive mechanism operatively coupled to the cleaning rod to impart mechanical motion to the cleaning rod. A cleaning media is connected to an end of the cleaning rod and has a thickness past the end of the cleaning rod of at least about 0.125 inches. The cleaning media preferably has

a thickness past the end of the cleaning rod of between about 0.125 inches and 0.5 inches, more preferably between about 0.3 inches and 0.4 inches past the end of the cleaning rod. Various alternative embodiments for the cleaning media include a swab, a brush, a pad, and a foam.

[0009] In other embodiments, the device may include a mating connector housing the cleaning rod without being operatively coupled to the drive mechanism and/or a resilient member coupled to the cleaning rod and biasing the cleaning rod in a direction along the main axis of the cleaning rod and towards the end of the cleaning rod having the cleaning media. In embodiments with a resilient member, the member may include a mechanical spring or a hydraulic spring or other springs familiar to those of skill in the art.

[0010] A preferred embodiment provides an optical connector cleaner device for cleaning a ferrule end surface of an optical connector. This embodiment includes a cleaning rod, a cleaning media connected to an end of the cleaning rod, and a drive mechanism operatively coupled to the cleaning rod to impart rotary motion to the cleaning rod. While the drive mechanism is preferably an electric drive mechanism, a pneumatic drive mechanism or other drive mechanisms may also be employed. The mechanical motion imparted to the cleaning rod and the attached cleaning media may include rotary motion and/or oscillating linear motion, either individually or in combination, or may include a more complex mechanical motion.

[0011] One preferred embodiment houses the drive mechanism, and potentially other portions of the device as well, in a handheld body. An alternative embodiment mounts the drive mechanism on a dummy card connector, wherein the dummy card connector is physically compatible with a slot in a card-cage. In a preferred version of this embodiment, the dummy card connector includes an adjustable frame which may be adjusted to modify card size in at least one

direction in order for the same dummy card connector to be physically compatible with more than one physical slot configuration and/or more than one card cage.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] **Figure 1** is a schematic drawing of a card connector version of the optical connector cleaner.

[0013] **Figure 2** is a schematic drawing of a hand-held version of the optical connector cleaner.

[0014] **Figure 2A** is a close-up drawing showing an extended or alternative configuration of a hand-held version of the optical connector cleaner.

[0015] **Figure 3A** is a close-up drawing of one version of the cleaning media.

[0016] **Figure 3B** is a close-up drawing of an alternative version of the cleaning media.

[0017] **Figure 3C** is a close-up drawing of an alternative version of the cleaning media.

[0018] **Figure 3D** is a close-up drawing of an alternative version of the cleaning media.

[0019] **Figure 3E** is a close-up drawing of an alternative version of the cleaning media.

[0020] **Figure 4** is a close-up drawing of a cleaner media and mating connector illustrating one method of operation.

[0021] **Figure 5** is a close-up drawing of a cleaner media and mating connector illustrating an alternative method of operation.

DETAILED DESCRIPTION OF THE INVENTION

[0022] The present invention may be used to easily and effectively clean the end of a ferrule of a fiber optic connector. Such ferrules may be mounted on a backplane in a telecom rack and

one version of the present invention is specifically configured to simplify access and alignment to clean such ferrules without need to remove them from their mounting. Such ferrules may also be mounted in other positions or may be withdrawn and held free of mounting. The present invention is equally capable of cleaning ferrules of fiber-optic connectors in these states as well.

[0023] **Figure 1** illustrates an embodiment of the present invention specifically configured to simplify cleaning the surface of a ferrule in a fiber optic connector mounted in a backplane of a card-cage. The optical connector cleaner device **10** is mounted on a dummy card **30** which has the physical connecting characteristics of the cards typically mounted in the card-cage or telecom rack for functional purposes, but does not carry any of the operative circuitry or other systems to interact with the backplane. The cleaner device **10** illustrated in Figure 1 includes a cleaning member **12** within a mating connector **14**. The cleaning member **12** is coupled to a drive converter **16** which provides mechanical movement to the cleaning member **12**. The drive converter **16** is powered by a power source **18**, which could represent a battery, a pneumatic source, or other power source as recognized by those of skill in the art. The drive converter **16** and power source **18** together make up a drive mechanism which may be pneumatic, electric, electromagnetic, or any other means of taking a relatively compact stored energy source and converting it to mechanical motion as recognized by those of skill in the art. The power source **18**, and hence the drive mechanism may, in the present embodiment, be initiated by use of a switch **20**. While the preferred embodiment of the present invention employs a simple mechanical motion (rotary motion or oscillating linear motion) as its cleaning motion, more complex drive mechanisms with more complex motion such as those disclosed in U.S. Patents 5,378,153 and/or 5,613,259 (both of which are incorporated herein by reference) could also be employed in combination with other aspects of the present invention.

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additional specifically sized dummy cards. Like the standard dummy card **30**, an adjustable frame dummy card could also be designed to permit reorientation of the cleaner device **10** and its mating connector **14** to clean connectors at different relative positions on the backplane. In one embodiment, an adjustable frame dummy card could also be configured to hold multiple devices **10** for those occasions when multiple connector ends are on the same backplane aligned with the same card slot in a card cage.

[0026] **Figure 2** illustrates the preferred embodiment of the optical connector cleaner device of the present invention where the cleaner device **10** is cased within a handheld body **40** for use by hand in any number of settings. The illustrated embodiment of the device **10** still incorporates the same elements of cleaning member **12**, mating connector **14**, drive converter **16**, power source **18**, and switch **20**. The body is illustrated in a rudimentary cylindrical shape, but may take on different configurations to accommodate easier gripping or manipulation or to better fit into extended cavities while still providing the ability to appropriately orient the cleaning media against the ferrules to be cleaned. As illustrated in the close-up view of **Figure 2A** to reach more distant ferrules, such as those installed in the backplane of a card-cage, an alternative embodiment features an extension **42** between the drive converter **16** and the cleaning member **12** and mating connector **14**. This extension could be a permanent additional length to allow greater reach, or could be an extendable section which may be expanded or contracted to allow for more compact storage or a compact state for entry into a restricted area, followed by extension for engagement with the ferrule to be cleaned.

[0027] In the embodiment illustrated in **Figure 2**, the device is held by hand. The user guides the device into the proper position activates the drive mechanism imparting mechanical motion to the cleaning member which results in the cleaning member and specifically the

cleaning media shearing across the surface of the ferrule and connector end. The proper position is one in which the cleaning member engages the surface of the ferrule and the cleaning media at the end of the cleaning member is at least slightly deformed against the surface of the ferrule. The ability of the cleaning media to deform to some degree is preferable and provides potential benefits in fit to the surface features, compensation for minor misalignment, and potentially may improve cleaning effect.

[0028] The use of a mating connector 14 is preferable for assisting in locating the proper position when the ferrule to be cleaned is itself mounted within a housing forming a corresponding mating connector. However, if the ferrule is not within a mating connector itself or even where the ferrule is within a mating connector, a mating connector 14 is not necessary for proper operation of the present invention.

[0029] An alternative embodiment of the present invention which is not illustrated would provide pressure control to attempt to simplify having the cleaning member contacting the ferrule end surface with a pressure within a particular range. This pressure control could be provided by a resilient member such as a mechanical spring or a hydraulic spring supporting the cleaning rod. In this manner, as the hand held device is put into position, the user would push the cleaning member into engagement with the ferrule end surface until the member started to retract against the spring force. The user would not push the member hard enough for it to reach the spring stop. There would thus be a range of movement where the force on the ferrule surface from the cleaning member would be sufficient to initially deform the spring but not so much as to push past the spring's capacity. This could help insure that sufficient force was supplied, but not too much force was supplied, potentially improving control. While this would be particularly useful for the hand held device without a mating connector, it could also provide advantages in

combination with a mating connector or even on the dummy card version of the device. The preferred ranges of force could be determined experimentally for different cleaning environments and different cleaning media. Some consideration could be given to spring loading done on the connectors themselves currently in the art as a guideline for spring construction and loads for cleaning members. Those of skill in the art could design the springs to meet the appropriate parameters for initial deflection and peak force.

[0030] Various potential cleaning members are illustrated in the collection of close-up **Figures 3**. While various potential media include swabs, brushes, fibers, foams, and pads, it is preferable that there be some depth to the cleaning media and some degree of deformability of the media to allow the media to conform to the surface features and surface orientation of the ferrules to be cleaned. While preferences may differ a small amount between different media and media structures, in general the depth of the cleaning media is preferably at least about 0.125 inches past the end of the cleaning rod, more preferably between about 0.125 inches and about 0.5 inches past the end of the cleaning rod, and most preferably between about 0.3 inches and about 0.4 inches past the end of the cleaning rod. Those of skill in the art may recognize additional configurations which provide these features which are likewise understood to be part of the scope of the present disclosure.

[0031] **Figure 3A** illustrates the currently preferred embodiment with a cleaning rod 50 and cleaning media 52 in the form of a swab, such as might be found on a cotton swab or on the more traditional swabs used for hand-cleaning of fiber-optic connectors. The preferred depth of the swab is at least 0.125 inches thick past the end of the cleaning rod 50 and more preferably within a range of 0.3 inches and 0.4 inches thick. The cleaning rod is preferably a relatively stiff member, while the cleaning media is preferably at least somewhat deformable, hence the length

or depth of the cleaning media past the end of the cleaning rod in this and other embodiments provides a range of deformability of the cleaning media before the stiff cleaning rod stops or significantly restricts additional deformation. The swab of **Figure 3A** is axially symmetrical making it particularly preferably for rotational cleaning.

[0032] **Figure 3B** illustrates a cleaning rod **60** and cleaning media **62** in the form of a brush, with bristles illustrated perpendicular to the end of the cleaning rod **60**. The bristles are preferably at least 0.125 inches long past the end of the cleaning rod **60**, and more preferably within a range of 0.2 inches and 0.5 inches long.

[0033] **Figure 3C** reflects an alternative bristle alignment where cleaning rod **70** has cleaning media **72** in the form of angled bristles. The angled bristles may provide more favorable abrading or shearing action on the ferrule surface. When used with a rotational cleaning approach, one embodiment would have the bristles angled about the central axis such that the direction of angle is always perpendicular to the rotational moment. The cleaning rod **70** and cleaning media **72** could either be rotated into the grain of bristles or against the grain of bristles as is more appropriate for best cleaning of the particular contaminants being removed. In this embodiment, the depth from the end of the bristle to the surface of the cleaning rod **70** is preferably at least 0.125 inches and more preferably within a range of 0.2 inches and 0.5 inches.

[0034] **Figure 3D** illustrates an alternative embodiment which may be particularly suited to side to side cleaning in which the cleaning rod **80** supports a cleaning media **82** which has towards its tip an angular slope to a line intersecting the central axis. Those of skill in the art will recognize the similarities between this shape and some foam “brushes” used for painting. The orientation would preferably be such that the line of intersection is perpendicular to the sweep direction. The media preferably extends at least 0.25 inches past the end of the cleaning

rod 80 at the media's shortest length and more preferably is within a range of 0.3 inches and 0.5 inches past the end of the cleaning rod 80 at the media's shortest length.

[0035] Figure 3E illustrates an alternative embodiment similar in configuration to Figure 3D, only replacing the foam or swab media with a cleaning media 92 made of fibers of varying lengths resulting in angles to a line intersecting the central axis. The shortest fibers preferably extend past the end of cleaning rod 90 at least 0.25 inches and more preferably a range of 0.3 inches and 0.4 inches between the shortest fibers and the end of the cleaning rod 90.

[0036] For the process of cleaning itself, the preferred method as illustrated in the close-up view of Figure 4 involves the drive mechanism using the drive converter 16 as a torque converter and spinning the cleaning member 12. When turning on the drive mechanism, the cleaning member 12 will spin about its axis and clean the end of the ferrule on a fiber connector. The cleaning member 12 is typically made up of a cleaning rod with a cleaning media such as a swab or brush on one end. The present illustration incorporates the use of cleaning media 52 as illustrated in Figure 3A, but other media as described in this specification and as understood by those of skill in the art could also be employed. The rotation may be clockwise or counterclockwise. In an alternative embodiment, the rotation may alternate back and forth between clockwise and counterclockwise in an effort to change the angle of attack and better remove certain resistant contaminants. An additional alternative method could replace the spinning or rotational cleaning with alternative mechanical approaches such as an oscillating side-to-side motion or corner-to-corner sweep or other mechanical motion as understood by those of skill in the art. A linear side-to-side sweeping motion as illustrated in the close-up view of Figure 5 may actually be preferable for cleaning multi-fiber connectors with a row of fibers contained within the same cubic ferrule. The present illustration incorporates the use of cleaning

media 82 as illustrated in **Figure 3D**, but other media as described in this specification and as understood by those of skill in the art could also be employed.

[0037] Although not preferred, the cleaning media may also be dipped with cleaning solvent for difficult cleanings. Such a cleaning solvent could include ethanol, for example, but a preferred solution would be quickly evaporative, leaving little or no residue, otherwise the cleaning solution may leave as much contaminant as it removes. One possible cleaning solution which could be incorporated would be the VF-45 solution from 3M (an HFE solution) which evaporates rapidly leaving little or no residue. Nevertheless, in the preferred embodiment of the present invention no solution is used in cooperation with the cleaning media at all. The thicker cleaning media of the present invention may also provide advantages in better absorbing either cleaning solution or contaminants (either with or without cleaning solution) and pulling the same away from the ferrule surface.

[0038] The cleaning member is preferably inexpensive, disposable, and easily replaced. The cleaning member is preferably installed so that it is co-centered with and supported by the mating connector, and coupled to the drive mechanism. The cleaning member may be directly connected to the drive mechanism or may be indirectly connected or operatively coupled to the drive mechanism. The term coupled is used to cover both direct connections and indirect connections.

[0039] Although only a few embodiments of the present invention have been described, it should be understood that the present invention may be embodied in many other specific forms without departing from the spirit or the scope of the present invention. The present examples are to be considered as illustrative and not restrictive, and the invention is not to be limited to the

details given herein, but may be modified within the scope of the appended claims along with their full scope of equivalents.

FOOTNOTES